TIME ALIGNMENT OF TRANSMISSION IN A DOWN-LINK OF CDMA SYSTEM

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FIELD OF THE INVENTION

The present invention relates to the use of Code Division Multiple Access (CDMA) communications techniques in cellular radio telephone communication systems, and more particularly, to a method using a Direct Sequence-Code Division Multiple Access (DS-CDMA) communication technique for aligning transmissions in macro-diversity down-links from more than one base station to the same mobile station.

BACKGROUND OF THE INVENTION

CDMA or spread spectrum communications have been in existence since the days of World War II. Early applications were predominantly military oriented. However, today there has been an increasing interest in using spread spectrum systems in commercial applications. Some examples include digital cellular radio, land mobile radio, and indoor and outdoor personal communication networks, generically referred to as cellular systems herein.

Currently, channel access in cellular systems is achieved using Frequency Division Multiple Access (FDMA) and Time Division Multiple Access (IDMA) methods. In FDMA, a communication channel is a single radio frequency band into which a signal's transmission power is concentrated. Interference with adjacent channels is limited by the use of band pass filters which only pass signal energy within the specified frequency band. Thus, with each channel being assigned a different frequency, system capacity is limited by the available frequencies as well as by limitations imposed by channel reuse.

In TDMA systems, a channel consists of a time slot in a periodic train of time intervals over the same frequency. Each period of time slots is called a frame. A given signal's energy is confined to one of these time slots. Adjacent channel interference is limited by the use of a time gate or other synchronization element that only passes signal energy received at the proper time. Thus, the problem of interference from different relative signal strength levels is reduced. With FDMA or TDMA systems or hybrid FDMA/TDMA systems, the goal is to insure that two potentially interfering signals do not occupy the same frequency at the same time.

Capacity in a TDMA system is increased by compressing the transmission signal into a shorter time slot. As a result, the information must be transmitted at a correspondingly faster burst rate which increases the amount of occupied spectrum proportionally.

In present systems, such as GSM (Global System for Mobile Communication), time-alignment of mobile stations in an up-link is used to ensure that a base station receives the signal from a mobile station in the assigned TDMA time-slot. An overlap into a neighboring time-slot, caused by different propagation delays for example, would cause interference with another mobile-to-base station link.

In contrast to FDMA and TDMA, Code Division Multiple Access (CDMA) allows signals to overlap in both time and frequency. CDMA signals share the same frequency spectrum in present day systems. In the frequency or the time domain, the multiple access signals appear to be on top of each other.

In principle, in a CDMA system the informational data stream to be transmitted is impressed upon a much higher rate data stream known as a signature sequence. Typically, the signature sequence data are binary, providing a bit stream. One way to generate this signature sequence is with a pseudo-noise (PN) process that appears random, but can be replicated by an authorized receiver. The informational data stream and the high bit rate signature sequence stream are combined by multiplying the two bit streams together, assuming the binary values of the two bit streams are represented by +1 or −1. This combination of the higher bit rate signal with the lower bit rate data stream is called coding or spreading the informational data stream signal. Each informational data stream or channel is allocated a unique spreading code.

A plurality of coded information signals modulate a radio frequency carrier, for example by quadrature phase shift keying (QPSK), and are jointly received as a composite signal at a receiver. Each of the coded signals overlaps all of the other coded signals, as well as noise-related signals, in both frequency and time. If the receiver is authorized, then the composite signal is correlated with one of the unique codes, and the corresponding information signal can be isolated and decoded.

One CDMA technique, called "traditional CDMA with direct spreading", uses a signature sequence to represent one bit of information. Receiving the transmitted sequence or its complement (the transmitted binary sequence values) indicates whether the information bit is a "0" or "1". The signature sequence usually comprises N bits, and each bit is called a "chip". The entire N-chip sequence, or its complement, is referred to as a transmitted symbol. The receiver correlates the received signal with the known signature sequence of its own signature sequence generator to produce a normalized value ranging from −1 to +1. When a large positive correlation results, a "0" is detected; when a large negative correlation results, a "1" is detected.

Another CDMA technique, called "enhanced CDMA with direct spreading" allows each transmitted sequence to represent more than one bit of information. A set of code words, typically orthogonal code words or bi-orthogonal code words, is used to code a group of information bits into a much longer code sequence or code symbol. A signature sequence or scramble mask is modulo-2 added to the binary code sequence before transmission. At the receiver, the known scramble mask is used to descramble the received signal, which is then correlated to all possible code words. The code word with the largest correlation value indicates which code word was most likely sent, indicating which information bits were most likely sent. One common orthogonal code is the Walsh-Hadamard (WH) code.

In both traditional and enhanced CDMA, generically referred to as Direct Sequence-Code Division Multiple Access (DS-CDMA), the "information bits" referred to above can also be coded bits, where the code used is a block or convolutional code. One or more information bits can form a data symbol. Also, the signature sequence or scramble mask can be much longer than a single code sequence, in which case a sub-sequence of the signature sequence or scramble mask is added to the code sequence.

In a conventional cellular communication systems such as AMPS, reliable handover between base stations is viable if the carrier frequency is not changed. Handoff procedure for handing a call link from one cell to another is initiated when the cell site receiver handling the call detects that the received signal strength from a mobile station falls below a